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Outcome of Surgery for Vascular Access in Patients Commencing Haemodialysis

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Objective: *assessment of surgical vascular access procedures for haemodialysis.*
Design: *retrospective cohort audit.*
Materials and Methods: *secondary patency was calculated from surgery until access failure, death, transplant, conversion to peritoneal dialysis, or loss to follow-up. All surgical procedures including immediate failures and failures to mature fistulae were included but not radiological interventions.*
Results: *four hundred and forty-five operations were undertaken in 197 patients over 87 months comprising 273 access creations and 172 revisions. Median follow-up was 26 months with a mortality of 9.4 deaths per 100 patient-years including eight perioperative deaths. Autogenous access was created in 147 (75%) patients with 142 based on the radial artery whilst 50 prosthetic grafts including 46 PTFE grafts and 40 forearm loops were placed. Patients receiving grafts were more likely to be older, female and die in follow-up. Grafts had higher patencies of 89, 75 and 68% at 1, 2 and 4 years, respectively compared to 69, 63 and 55% for autogenous access. This difference was significant* ($p = 0.049$) *when the effects of the presence of diabetes and peripheral arterial disease were accounted for but more frequent revisions were required. The final access placed was autogenous in 110 (56%) and prosthetic in 87 (44%) patients.*
Conclusions: *in our surgical unit, there was high secondary patency including for prosthetic grafts, high autogenous utilisation and relatively infrequent reintervention.*

Key Words: Haemodialysis; Access; Surgery; Outcome.

Introduction

The requirement for haemodialysis services is increasing by approximately 7% per annum.[1] Creation and maintenance of haemodialysis access consume a considerable portion of resources used in the management of chronic renal failure as well as accounting for up to one-third of admissions. The aim of this study was to determine the outcome of surgical procedures undertaken for haemodialysis access in a single vascular surgical Unit.

Methods

The primary and secondary patencies of consecutive new adult referrals for haemodialysis accesses established by a vascular surgical unit within a tertiary referral hospital were reviewed. A single senior vascular surgeon undertook or supervised all surgery for the first 75 months of the review period from 1 January 1994. A second senior surgeon within the unit also undertook vascular access surgery for the 12 months before the close of the review period on 31 March 2001.

Patient and operative details were obtained from the Unit database with additional and follow-up data obtained as required from the Australia and New Zealand Renal Registry (ANZDATA), hospital medical records and the specialist's records. All required records were obtained for review. Conduct of this review was approved by the Institutional Ethics Committee.

The policy for the establishment of access was for an arteriovenous fistula to be created whenever possible in the non-dominant forearm. When on clinical assessment, the cephalic vein in the forearm was unsuitable for anastomosis, unlikely to mature or the radial artery pulse was absent, alternative access was considered. Generally, this was placement of a prosthetic graft in the non-dominant forearm but in selected cases, the upper arm or dominant forearm was used for creation of a fistula. Saphenous vein grafts were used occasionally in the early and middle period of the review period but were abandoned because of a perceived high rate of subsequent stenosis and occlusion compared to both direct fistulae and

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prosthetic grafts, the initial requirement for general rather than regional or local anaesthesia and the additional patient discomfort of the vein harvest site. Access in the thigh was placed as a loop in the mid-thigh to the superficial femoral vessels with all incisions well clear of the groin. In patients expected to require self-cannulation, access was always placed in the non-dominant forearm even if this required placement of a prosthetic graft in the forearm rather than a fistula in the upper arm. The potential for earlier utilisation of grafts compared to fistulae was not considered in the decision as to the type of access placed. The decision to place further access, and the site and type of access were made on a patient by patient basis without a formal clinical pathway.

Preoperative assessment with ultrasound of the forearm, cubital fossa and subclavian veins was not routinely undertaken. A small number of highly selected patients in whom clinical examination was unable to identify suitable cubital fossa veins underwent duplex scanning to assess the superficial veins of the cubital fossa and upper arm. Examination of the central veins was only undertaken if there was a history of central venous cannulation and symptoms or signs suggestive of central venous stenosis or occlusion. All haemodialysis access procedures were undertaken with the intention of creating or maintaining long-term haemodialysis access and none were undertaken for temporary access.

Patients not yet on haemodialysis received between 2500–5000 IU unfractionated heparin intra-operatively depending on their weight and patients already on haemodialysis via temporary catheters between 0 and 5000 IU heparin. Post-operatively, patients not yet on dialysis generally took low-dose aspirin until haemodialysis commenced. Preoperative screening for thrombophilic states was not routinely undertaken but patients with subsequent recurrent unexplained access thrombosis were screened for thrombophilic states and selectively anticoagulated. Antibiotic prophylaxis was a single dose of 1 g of cephalothin at the time of surgery with vancomycin used in patients receiving prosthetic grafts with temporary central venous catheters present at the time of surgery or a significant history of adverse response to cephalosporins.

Following surgery, patients with clinically adequate access commenced haemodialysis without further imaging. Patients with autogenous access thought to be unsuitable or unable to be accessed underwent progress clinical assessments and fistulography to help decide whether to attempt revision or abandon that access. Patients on haemodialysis with low flow or high venous pressures were also referred for angiography to determine if a correctable lesion was present. There was no policy of routine screening of accesses with duplex scanning or other investigations. Only web-like stenoses were thought to be suitable for balloon dilatation. Diffuse stenosis at the venous anastomosis thought to be due to intimal hyperplasia was treated surgically with either patch angioplasty or extension of the graft to proximal veins. After access thrombosis, the decision to attempt salvage or abandon the access and construct new access was clinically based. Further intervention was usually surgical rather than radiological. Thrombolysis was rarely undertaken and only after the cause for the thrombosis had been identified and reversed or eliminated.

Accesses were classified and patencies analysed using categories and methods very similar to the recently published US reporting guidelines for vascular access. Secondary patency was defined as the maintenance of haemodialysis access adequate to sustain effective haemodialysis. Accesses that occluded and in which patency was unable to be reestablished, failed to mature, failed immediately, became unable to be cannulated or required substantial replacement were deemed to have failed. Patency was measured from the date of creation of the access to the date of failure with the assessment of patency censored by transplantation (successful or otherwise), death, withdrawal from dialysis, conversion to peritoneal dialysis (CAPD), transfer to other surgical Units or loss to follow-up. All surgical interventions undertaken were included in the review and analysed separately including immediate failures and procedures to superficialise veins. Multiple procedures within a single operation were counted as a single operation but returns to theatre on the day of surgery were analysed as additional procedures ie failed primary patency.

Accesses electively closed after transfer to CAPD or successful transplant were already censored and therefore were not defined as failures unless already deemed so prior to censoring. If the access occluded and patency was reestablished, even if placement of temporary central venous access was required, then secondary patency was defined as maintained. If the access was substantially replaced with a long interposition graft, the existing access was defined as having failed and a new access established. However, placement of a short interposition or extension graft was defined as maintaining the secondary patency of the existing access.

Primary patency was defined as patency free of any surgical intervention. Radiological interventions were not assessed and assisted primary patency was not determined.

Patency rates and the association of risk factors were calculated and compared using chi squared and *t*-tests, Kaplan–Meier plots and log-rank tests and Cox proportional hazards regression.

Results

Over 87 months from January 1994 to March 2001, 197 patients with no prior permanent haemodialysis access were referred for the establishment of permanent vascular access. Overall, 273 accesses were placed and 172 revision procedures undertaken. The total follow-up was 426 patient-years, with a mean (median, interquartile range) follow-up of 26 (21, 7–38) months per patient. Nine patients underwent their initial surgery within three months of study closure, 109 (55%) patients were censored by closure of the review period, 40 (20%) patients died, 25 (14%) underwent transplantation, four (2%) patients converted to CAPD and 19 (10%) transferred to other haemodialysis units or were lost to follow-up. There were four deaths within 30 days of the patient's first operation to establish access and a further four following subsequent operations, giving a perioperative mortality of 2.0% for the patient's initial procedure and an overall perioperative mortality of 1.8%. The overall patient survival is shown in Figure 1.

The mean (median, interquartile range) age at initial surgery over the study period was 61 years (65, 51–73). The minimum age was 18 years and the maximum was 88. In the ANZ Renal Registry, the mean (median) age at commencement of haemodialysis in 1994 in New South Wales was 54 (58) years, and in 1999, 58 (61) years. The average age at surgery in our Unit each year has been consistently greater than the average age of commencement of haemodialysis in NSW between 1993 and 2001 with a mean (median) difference of 5.5 (5.3) years (Fig. 2).

Fifty-eight percent of patients were male. Comorbidities defined according to ANZDATA criteria were recorded at initial surgery in 193 patients. Chronic obstructive airways disease (COAD) was present in 10%, coronary artery disease (IHD) in 42%, peripheral vascular arterial disease (PVD) in 20%, cerebrovascular disease in 12% and hypertension (HT) in 90%. Diabetes was present in 23%; comprising 7% non-insulin dependent diabetics managed with diet or oral hypoglycaemic agents, 7% non-insulin dependent diabetes managed with insulin and 9% insulin dependent diabetics.

Increased age, IHD, PVD, prosthetic graft use and COAD were all associated with subsequent mortality on univariate analysis but on multivariate analysis, only age was associated with subsequent mortality (Table 1) with a more than doubling of risk of mortality per decade of age.

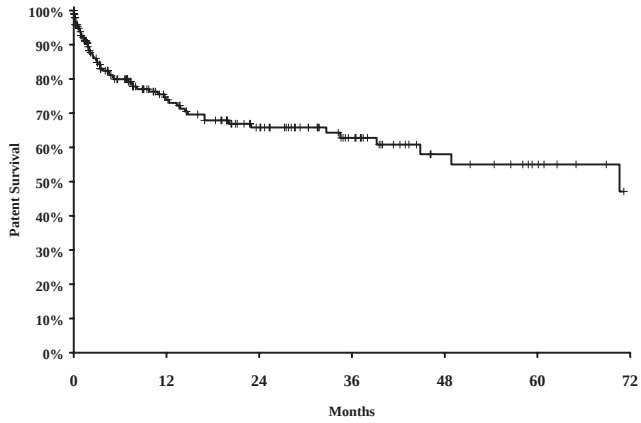

Fig. 1. Kaplan–Meier plot showing patient survival. Censored patients shown (+). Data points shown for SE < 10% and six or more patients.

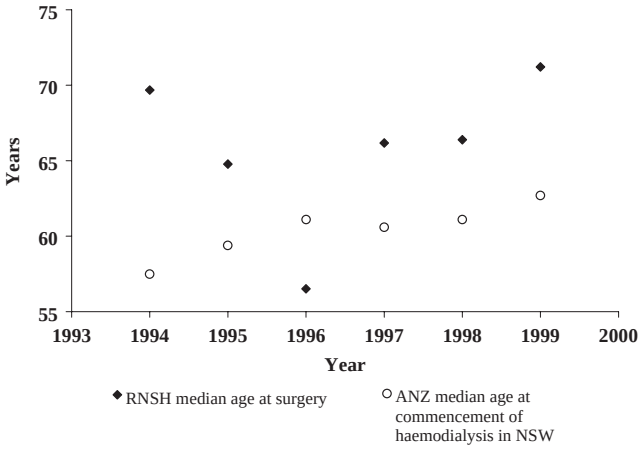

Fig. 2. Median age at surgery for patients commencing haemodialysis in our review (◆) compared to median age when commencing haemodialysis in NSW in ANZDATA (○)

Table 1. Univariate and multivariate analysis of factors associated with patient mortality.

	Hazard ratio	95% CI	*p*
Univariate			
Age (per decade)	2.16	1.51–3.05	< 0.001
PVD	2.23	1.16–4.28	0.016
IHD	2.18	1.14–4.18	0.018
COAD	2.42	1.14–5.14	0.021
Prosthetic graft	2.00	1.06–3.76	0.033
Cerebrovascular Δ, sex, hypertension, diabetes			> 0.10
Multivariate			
Age (per decade)	2.16	1.51–3.05	< 0.001

The initial access required 281 operations to establish and maintain function and the 197 patients overall required 273 separate accesses and 445 operations. The average number of operations per patient undertaken was 2.1, the average number of accesses created per patient was 1.4 and the average number of operations required per access was 1.6 (Figs 3–5). The average number of operations for the initial access was 1.4. One hundred and forty-four patients (73%) required establishment of only a single access and 102 (80%) required only a single operation to establish and maintain that access. The 95 patients who required more than one operation to establish access required a further 248 operations (2.6 further operations per patient), with the 53 patients whose first access failed requiring a further 74 accesses (1.4 further accesses per patient) and 164 further operations (3.1 further operations per patient).

The secondary and primary patencies of the first access placed are shown in Figure 6. At 60 months, the overall primary and secondary patencies of the first access were 29 and 55%.

Of the initial accesses placed, 147 (75%) were autogenous and 50 were prosthetic grafts. Patients who had prosthetic accesses initially placed were significantly more often female, older and likely to die in follow-up than those receiving autogenous access.

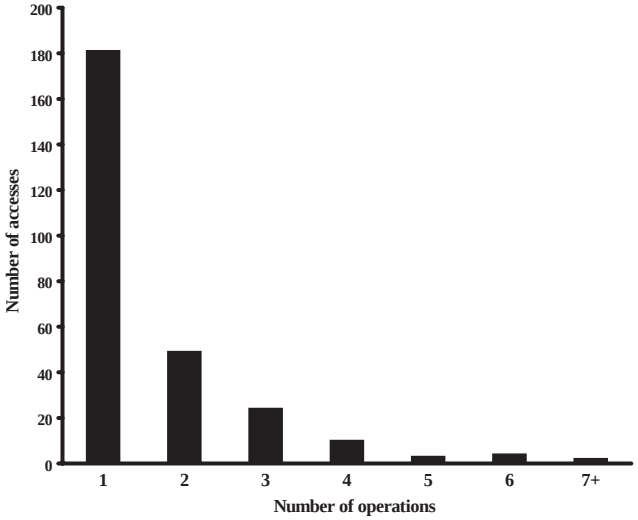

Fig. 3. Frequency histogram of 445 operations undertaken on 273 accesses.

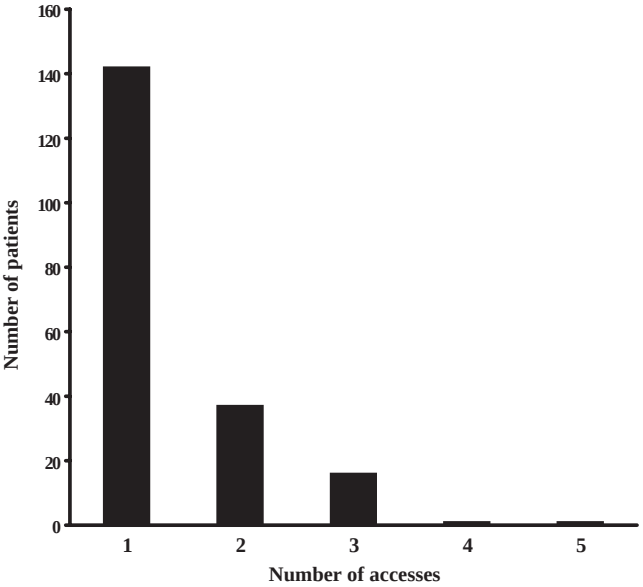

Fig. 4. Frequency histogram of 273 accesses placed in 193 patients.

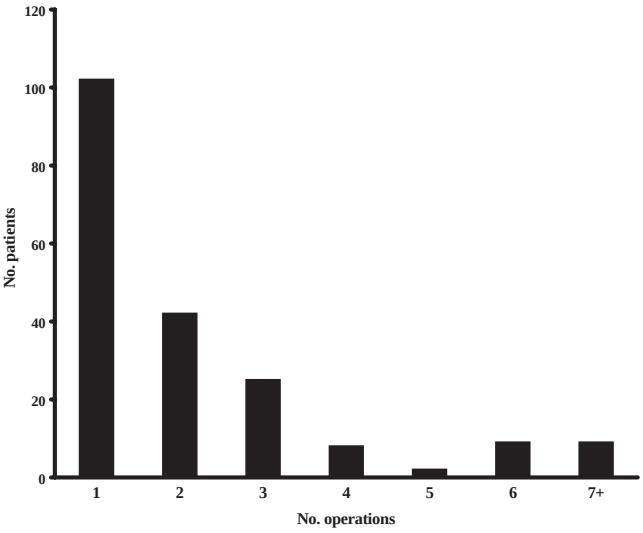

Fig. 5. Frequency histogram of 445 operations undertaken on 193 patients.

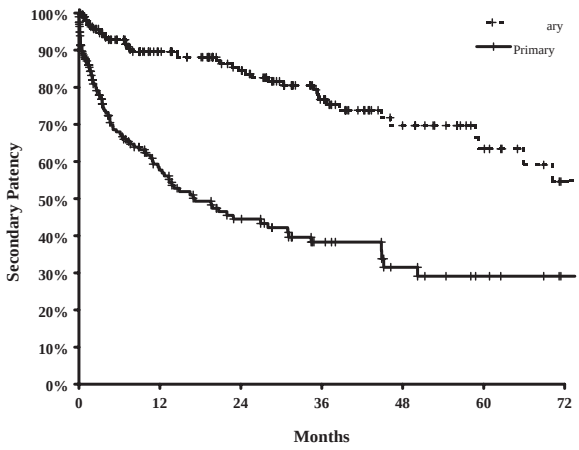

Fig. 6. Kaplan–Meier plot of secondary (---) and primary (——) patencies of initial accesses placed. Censored patients shown (+). Data points shown for SE < 10% and six or more five patients.

A similar but not significant trend to be diabetic, to have PVD and IHD (Table 2) was also present.

Of the initial accesses placed, all but five autogenous accesses were placed at the wrist with the remainder in the cubital fossa. Of the 50 grafts, there were 46 PTFE and four polyurethane grafts. Nine grafts were placed in a straight configuration from the wrist, one was placed as primary access in the thigh and the remaining 40 grafts were loops from the brachial artery. The initial and subsequent accesses placed and final access in use are shown in Table 3; autogenous access was present in 56% of the 197 patients with functioning access at study closure or censoring.

In addition to the grafts initially placed that thrombosed, four (8%) prosthetic grafts developed infection in the medium or longer term requiring revision although all were salvaged by excision and local bypass. A further two loop grafts, both in females, developed steal sufficient to require graft closure and one graft developed a false aneurysm requiring intervention but not closure. In the further 60 grafts placed subsequently, there were three infections requiring surgical intervention giving an overall infection rate of 6%, as well as the development of steal and aneurysm in two other patient (Table 4).

Table 2. Differences in characteristics of patients initially receiving autogenous or prosthetic access.

Factor	Autogenous	Prosthetic	*p*	Overall
Male	66%	36%	<0.001	58%
Subsequent Mortality	16%	32%	<0.001	20%
Mean Age (yrs)	59	65	0.006	61
Diabetes	20%	32%	0.07	23%
PVD	16%	28%	0.07	19%
IHD	39%	52%	0.10	42%
Hypertension			>0.30	90%
Cerebrovascular Δ			>0.30	12%
COAD			>0.70	10%

Table 3. Initial, subsequent and final accesses placed.

Type	Initial	Further	Total	Final
Autogenous	147 (75%)	16 (21%)	163 (60%)	110 (56%)
Direct fistula	143	10	153	104
Translocated LSV	4	6	10	6
Radial	142	12	154	103
Brachial	5	4	9	7
Prosthetic	50 (25%)	60 (79%)	110 (40%)	87 (44%)
Forearm loop	40	19	69	56
Forearm straight	9	17	26	21
Thigh loop	1	14	15	11
PTFE	46	58	104	87
Polyurethane	4	2	6	3
Total	197	76	273	197

The secondary patency of autogenous access was less than that of prosthetic grafts; 76, 69, 63 and 55% compared to 91, 89, 75 and 68% at 6, 12, 24 and 48 months respectively (Fig. 7), although the difference was not significant. The secondary patency was significantly increased in the presence of diabetes (Table 5) with a trend for reduced patency in the presence of autogenous access. After allowance was made for the presence of diabetes and PVD, the

Table 4. Development of complications in accesses requiring revision but not necessarily excision or closure.

	Complications	Number at risk	Rate (%)
Infection	7	110 grafts	6
Steal	3	110 grafts	3
Aneurysm	2	273 accesses	1

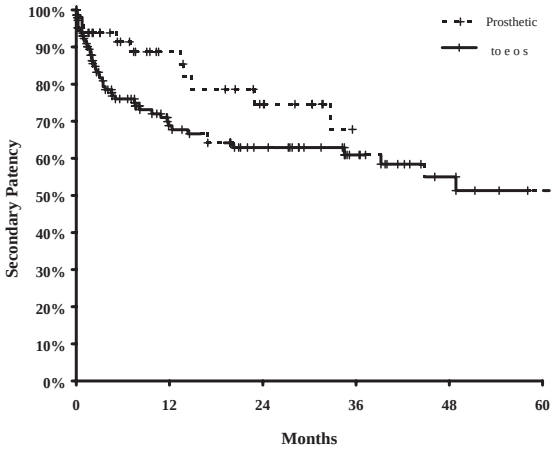

Fig. 7. Kaplan–Meier plot of secondary patencies of initial accesses placed in new referrals for dialysis comprising 50 prosthetic (---) and 147 autogenous (——) accesses. Censored patients shown (+). Data points shown for SE < 10% and for six or more remaining accesses.

Table 5. Univariate and multivariate analysis of factors associated with failure of access secondary patency (factor greater than 1 associated with increased failure).

	Hazard ratio	95% CI	*p*
Univariate			
Diabetes	0.44	0.21–0.93	0.032
Autogenous	1.83	0.93–3.61	0.082
COAD	1.75	0.88–3.47	0.11
PVD	1.55	0.85–2.84	0.15
Sex, age, IHD, Cerebrovascular Δ, hypertension			>0.25
Multivariate			
Diabetes	0.39	0.18–0.84	0.016
PVD	2.07	1.11–3.85	0.023
Autogenous	2.00	1.00–3.97	0.049

patency of prosthetic grafts compared to autogenous access was significant ($p = 0.049$) with the difference in patency partly to be due to the failure of 22% of autogenous accesses within 6 months. Failure rates of autogenous access patent for six months or longer were similar to prosthetic grafts. The causes of the early autogenous failures were not formally categorised but were predominantly due to failure of fistulae to mature. Fistulae that thrombosed early were generally not revised when the veins were judged to be marginal.

However, autogenous accesses required significantly ($p < 0.01$) fewer additional operations (0.3) than the grafts (0.8) to maintain function. Similar numbers of reinterventions were undertaken for subsequent accesses. For the first accesses placed, revisional procedures were undertaken on average every 50 months for autogenous accesses and 18 months for grafts and for subsequent accesses, every 17 months for autogenous access and 11 months for grafts. Overall, after the initial operation to establish access, patients underwent further surgery on average every 20 months.

Discussion

Comparisons of the outcomes of vascular access patency are necessarily limited by the wide variation in the method of reporting of results. Some studies exclude immediate failures, fistulae failing to mature and accesses removed because of sepsis. Others calculate patency from each intervention, i.e. "interval" patency rather than overall secondary patency, whilst others calculate patency from first cannulation rather than the date of creation of the access.

Recently, formal standards and definitions have been proposed for reports in the United States[2] of the outcomes of vascular access procedures. The defined outcomes used in our report are generally consistent with those and in particular the definition of secondary patency is the same. It may be argued that the calculation of patency from the creation of the access, rather from the date of first cannulation, results in an increased apparent duration of patency. However, the inclusion of all access revisions and failures prior to the use of the access reduces the overall patency. In our review, fistulae failing to mature were defined as patent until they were determined to be unable to be used for access rather than retrospectively determining the date of failure as that of the initial surgery.

Furthermore, the purpose of this study was to analyse outcome by intention to treat ie to include all accesses placed when it was intended for the patient to undergo haemodialysis whether or not the patient eventually used the access. Therefore, the results of all patients who died before their access was used, patients undergoing transplantation and patients in whom attempts to establish haemodialysis access are abandoned due to thrombophilic states or sepsis are also included. Measurement of patency from the date of first cannulation will necessarily exclude these patients and therefore increase apparent patency rates. Similarly, inclusion of only those patients recorded in Renal Registries may also exclude accesses failing before registration. Other events such as procedure-related death would potentially also not be reported. Overall, these effects on patency are reduced with longer and more complete patient follow-up.

Access has been classified as autogenous or prosthetic. This includes saphenous vein grafts as autogenous access. However, it may be argued that the haemodynamics of accesses based on saphenous vein translocated to the arm are more similar to those using prosthetic grafts than of direct fistulae and that these saphenous vein grafts should be grouped with prosthetic grafts.

There have been two recent reports[3,4] of the outcomes of surgery for haemodialysis vascular access using longitudinal data collection of a random sample of patients. These figures should serve to illustrate current practice and outcomes although only patients reported to the appropriate Registry can be included with patients undergoing access creation but undergoing transplantation, choosing not to commence dialysis or dying before haemodialysis commences not being included. Furthermore, the DOPPS study measured patency from the date of first usage, and presumably excluded all accesses failing before first use. This study also included all patients on haemodialysis rather than those commencing treatment.

In our series of patients referred for commencement of haemodialysis, the secondary patency of autogenous access at 3 and 4 years of 62 and 56% are comparable to the patencies 64–72% and 37–72% reported between 1982 and 1996 in a recent U.K. review of vascular access.[5] However, there has been a steady increase in the number and age patients referred for haemodialysis with a concomitant increase in significant comorbidities so conclusions drawn from direct comparison of patencies with series from previous time-periods must be cautious.

Our results at 24 months (63%) are comparable to the 64% recently reported by the United States Renal Dialysis System Dialysis Morbidity and Mortality Study in a random sample of 1583 patients

commencing haemodialysis.[3] The results at two years are similar to those in the US portion of the DOPPS study but only one-year patency was reported for the European portion of that report. The patient demographics seem similar to our patients. In a local report,[6] the patency of autogenous access was almost 90% but the mean age of patients at the start of dialysis was 57 years compared to 61 at surgery in our series, the type of access was unknown in 8.5% of patients, the type and site of fistulae created not stated and patients with less than three months follow-up were not included, potentially excluding patients with early occlusion, and death or early loss to follow-up. It was also unclear if patients with access created but not in use were included.

However, unlike the U.S. report, the U.K. review and the local series, the secondary patency of prosthetic grafts in our report was significantly higher than for autogenous access with secondary patencies at 2 and 3 years of 75 and 68% compared to 60% at 2 years in the U.S. review, 40–59% at 3 years in the U.K. review and 50 and 50% at 2 and 3 years in the Australian report. Like the U.S. and Australian reports, a higher rate of reintervention for grafts compared to autogenous access was required but the absolute rate of reintervention in our series was substantially lower; despite the mean follow-up being more than double and losses to follow-up half that of the U.S. series, patients required a comparable average number of accesses (1.4 compared to 1.4) and fewer revisions (0.9 compared to 1.2). Furthermore, although the secondary patency of autogenous access in our series was only slightly lower than in the US study, the fistula creation rate was substantially greater at almost 75% compared to 30%. Despite the early failure of 22% of autogenous accesses, the final access used was autogenous in 56% of patients and almost all of these were radiocephalic fistulae. The final access used was not reported in the U.S. series, although it is reported that overall 181 (26%) of the 672 fistulae created were vein transpositions whilst in our series all but 10 of the 163 autogenous accesses created were direct fistulae.

In the DOPPS study, although there was a high rate of autogenous use, the location of the access was not stated and patency was only assessed from first use rather than from the date of surgery. In our series, autogenous accesses remaining patent for more than 3 months had a very low subsequent failure rate. We hypothesise that the patency of our autogenous access would have been similar to the DOPPS study if a similar method of assessment of had been used.

It has been our practice to attempt to create a radiocephalic fistula whenever considered possible. Whilst it may be argued that the early failure of almost 20% of autogenous accesses, principally radiocephalic fistulae perhaps represents an over-optimistic choice of first procedure or vessel, the final proportion of patients using radiocephalic fistulae as their access is very high at over 50% of all patients. We contend that the attempted creation of a fistula carries little mortality and morbidity. If the outcome of these fistulae could be better predicted then initial autogenous access in an alternate site could presumably be created. However, in Australia, the rate of home haemodialysis is approximately 15% with an absolute requirement for ease of access with cannulation in either the non-dominant forearm or dominant thigh. Furthermore, it is felt that cannulation is easier and patient comfort better with access in the forearm, even in satellite haemodialysis units, although we have no objective data to support this contention. However, in our experience the creation of access using a prosthetic loop in the forearm, when it is judged that a radiocephalic fistula is unsuitable, appears reasonable given the high patency and low infection rates of the prosthetic grafts placed in our experience. We do accept that there will be a higher rate of reintervention required to maintain patency for these grafts but argue that should these patients have had autogenous access based on the brachial artery, there would be a higher rate of reintervention for venous aneurysm formation and steal than those accesses based on the radial artery.

Perhaps it is now appropriate to undertake a randomised trial to determine the most effective haemodialysis access if a radiocephalic fistula is judged unsuitable or has failed.

Grafts placed in the thigh in our study were anastomosed to the superficial femoral artery and vein in the mid-thigh rather than in the inguinal area. We believe that this approach reduces the rate and minimises the complications of sepsis by increasing the distance of the access and of the cannulation site from the groin.

Whilst radiological interventions such as angioplasty and thrombolysis have been used to maintain or salvage the patency of haemodialysis access, these procedures were not included in this analysis as the general policy of intervention in this Unit was for surgical interventions. Few radiological interventions were undertaken, and these were generally not initiated by the surgical team. The perception was that the success of radiological procedures alone was very modest and usually required subsequent surgical intervention within a short period so there would be little or no difference in the duration of secondary patency but an increase in the number of interventions required to maintain patency.

Other interventions proposed to increase access patency are not currently routinely undertaken in our Unit. It has been proposed[7] that preoperative duplex scanning improved outcomes by detecting occult proximal major vein stenoses and increasing autogenous access utilisation. However, even after the adoption of this approach, the fistulae utilisation and patency of that group was still less than in our report. Hypercoagulable or prothrombotic states are reported to occur in a high proportion of patients receiving haemodialysis.[8] As well as retrospectively suspecting patients of being hypercoagulable by otherwise unexplained access thrombosis, preoperative screening may also identify these patients. However, the precise conditions to screen for given the cost and variety of tests available is unclear as is the subsequent appropriate management once an abnormality is detected.

In our surgical Unit over an extended period, there was high autogenous utilisation, relatively infrequent reintervention and high secondary patency including for prosthetic grafts. We believe that a well functioning radiocephalic fistula provides the ideal access for haemodialysis, the site and type of the next best access is less clear and further research is required.

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